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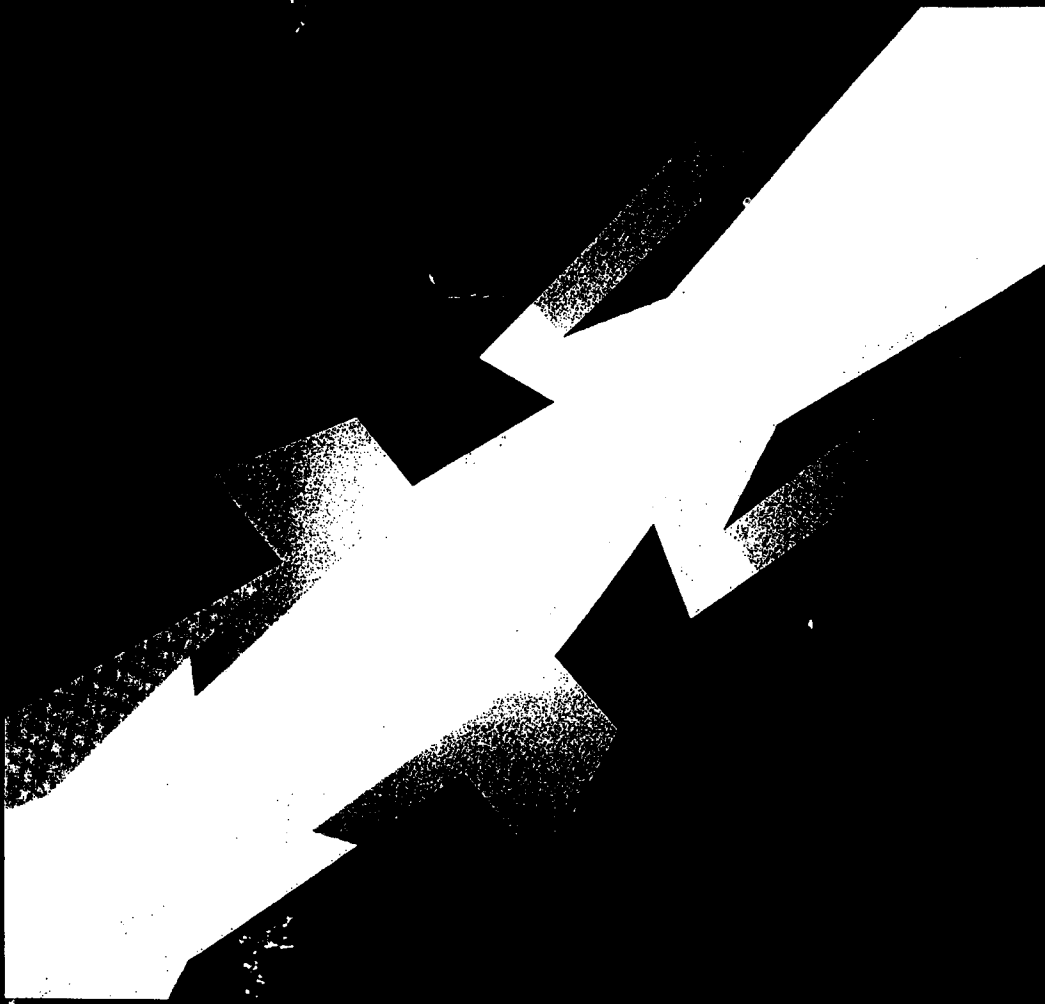Redacted

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Exhibit R

READINGS IN

HUMAN-COMPUTER INTERACTION

A MULTIDISCIPLINARY APPROACH

WRITTEN AND EDITED BY

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Readings in Human-Computer Interaction:
A Multidisciplinary Approach

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at CHI+GI '87, "What good is all this power if you lay waste to the literate landscape?"

Rosen (1963) presents a catalog of classic typefaces whose grace and expressiveness put to shame the typical appearance of our screens and print-outs. Ruder (1967) presents a rich body of evocative examples showing some of the uses and appearances of typography within design.

Our reading by Bigelow and Day (1983) introduces some of the issues of digital typography including letter-form design, representation of digital letterforms, letter-form quality, legibility and readability of digital text at different resolutions, and the problem of *aliasing*. More comprehensive treatments may be found in Seybold (1984), which presents digital typesetting in the context of the entire typesetting and printing process, and Rubin-stein (1987), which pays particular attention to the tech-nology of composition and layout.

Within the literature of computer science, Witten (1985) presents the fundamentals of computer typogra-phy and some solutions to the difficult problems of line breaks, hyphenation, justification, and page makeup. Up-to-date bibliographies of computer typography may be found in van Vleet (1986) and Naiman (1985a, 1985b). Of particular interest in the latter documents is an investigation of issues related to the display of coloured text for optimal legibility.

There is also much to be learned from the literature on the legibility and readability of typography. Tinker (1963, 1965) and Huey (1968) present some classic research on the legibility of type and on the psychology of reading. Hartley (1978, 1980), Kolers, Wrolstad, and Bouma (1979, 1980), Felker (1980), and Felker et al. (1981) are more modern collections of articles on the readability of documents and structured text.

Generally, text on screens has been found to be less legible than text on paper. Gould (1986) surveys much of the relevant literature and presents the results of some experiments that fail to explain why this is so, but demonstrate some of the contributing factors. More recently, Gould et al. (1986, 1987) show that reading speeds equivalent to that on paper may be obtained through the use of high-quality anti-aliased fonts displayed with dark characters on a light background on a high resolution screen.

Pictures, Symbols, Signs, and Icons

Human-computer interfaces increasingly incorporate images as well as text. Arnheim (1969) states that images can function as *pictures*, *symbols*, and *signs*.

> An image serves merely as a *sign* to the extent to which it stands for a particular content without reflecting its characteristics visually... Images are *pictures* to the

extent to which they portray things located at a lower level of abstractness than they are themselves. They do their work by grasping and rendering some relevant quali-ties — shape, colour, movement — of the objects or activities they depict... An image acts as a *symbol* to the extent to which it portrays things which are at a higher level of abstractness than is the symbol itself... .

One trend in user interfaces, arising from advances in computer graphics, is the incorporation of increasingly realistic three-dimensional portrayals (Greenberg, 1982). Mills (1982, 1985) suggests that this by itself is not sufficient to make optimal use of the medium of com-puter graphics, and argues that we need also pay atten-tion to the insights into pictorial representation and com-munication that arise out of art, art history, design, and the psychology of visual perception (Arnheim, 1974; Gombrich, 1961). Mills shows how man's background, history, and knowledge are embodied in his "cognitive schemata" and his capacity for metaphorical thinking, and how the choice of pictorial representation can facili-tate his understanding of images and his problem solving ability. The imaginative and appropriate choice of visual representation is thus a key determinant of the success of a user interface.

Another trend is that of incorporating in the interface *icons*, images representing system commands, objects, states, or results. Many icons function as pictures. For example, a schematic pen maybe used to indicate that the user may now paint, or a short thick line can indicate that lines about to be input will be drawn with a thick stroke. Some icons function as symbols, as for example, in the use of an hourglass, watch, or "smiling Buddha" to indicate that the system is working and the user should be patient.

The design of icons is a demanding craft. Dreyfuss (1972) has catalogued the incredible variety of icons in his guide to some of the 20,000 known international graphic symbols. The AIGA, American Institute of Graphic Arts (1981), has analyzed the strengths and weaknesses of passenger/pedestrian-oriented symbols in three distinct dimensions: *semantic*, *syntactic*, and *prag-matic*:

> The *semantic* dimension refers to the relationship of a visual image to a meaning. How well does this symbol represent the message? Do people fail to understand the message that the symbol denotes? Do people from vari-ous cultures misunderstand this symbol? Do people of various ages fail to understand this symbol? Is it difficult to learn this symbol? Has this symbol already been widely accepted? Does this symbol contain elements that are unrelated to the message?
>
> The *syntactic* dimension refers to the relationship of one visual image to another. How does this symbol look? How well do the parts of this symbol relate to each other? How well does this symbol relate to other symbols? Is the construction of this symbol consistent in its use of figure/ground, solid/outline, overlapping, transparency,

orientation, format, scale, colour, and texture? Does this symbol use a hierarchy of recognition? Are the most important elements recognized first? Does this symbol seriously contradict existing standards or conventions? Is this symbol, and its elements, capable of systematic application for a variety of interrelated concepts?

The *pragmatic* dimension refers to the relationship of a visual image to a user. Can a person see the sign? Is this symbol seriously affected by poor lighting conditions, oblique viewing angles, and other visual 'noise'? Does this symbol remain visible throughout the range of typical viewing distances? Is this symbol especially vulnerable to vandalism? Is this symbol difficult to reproduce? Can this symbol be enlarged and reduced successfully?

The complexity of the task of icon design is illustrated in the reading in which we excerpt some pages from AIGA (1981) showing the evaluation of possible designs for icons representing "information," "arriving flights," and "exit." We will return to the use of icons in user interfaces in Chapter 10: Interaction Styles and Techniques and in Case Study D: The Star, the Lisa, and the Macintosh.

Charts, Graphs, Maps, and Diagrams

A special class of images used increasingly in computer-generated displays are those portraying quantitative data, geographic data, and complex symbolic relationships. This is done by encoding and interpreting the data and relationships in a chart, graph, map, or diagram. The formulation and generation of intelligent varieties of these images can contribute significantly to the communicative and expressive power of computer displays.

No individual has presented this case more eloquently than Edward R. Tufte (1983). His goal is *graphical excellence*, which he defines as "the efficient communication of complex quantitative ideas":

Excellence in statistical graphics consists of complex ideas communicated with clarity, precision, and efficiency. Graphical displays should:

- show the data
- induce the viewer to think about the substance rather than about methodology, graphic design, the technology of graphic production, or something else
- avoid distorting what the data have to say
- present many numbers in a small space
- make large data sets coherent
- encourage the eye to compare different pieces of data
- reveal the data at several levels of detail, from a broad overview to the fine structure
- serve a reasonably clear purpose: description, exploration, tabulation, or decoration
- be closely integrated with the statistical and verbal description of a data set.

"Graphics *reveal* data," says Tufte. He then presents in his beautiful book "a language for describing graph-

ics and a practical theory of data graphics." He concludes with humility and a healthy skepticism:

Design is choice. The theory of the visual display of quantitative information consists of principles that generate design options and that guide choices among options. The principles should not be applied rigidly or in a peevish spirit; they are not logically or mathematically certain; and it is better to violate any principle than to place graceless or inelegant marks on paper. Most principles of design should be greeted with some skepticism, for word authority can dominate our vision, and we may come to see only through the lenses of word authority rather than with our own eyes.

What is to be sought in designs for the display of information is the clear portrayal of complexity. Not the complication of the simple; rather the task of the designer is to give visual access to the subtle and the difficult — that is, *the revelation of the complex.*

Those wishing to learn about the art of "the revelation of the complex" will need to supplement the Tufte book with additional readings. The next source to consult is Cleveland (1985), which presents principles of graphical construction, a catalog of appropriate graphical methods, and a paradigm for graphical perception. The use of a theory of visual perception and experimental results on visual perception to guide the design of displays is a welcome addition to the literature.

Three valuable books with a nice "how-to" flavour are Spear (1969), Schmid and Schmid (1979), and Schmid (1983). These three books, as well as the classic by Huff (1954), include illustrations of what not to do, that is, how to lie with graphic presentation. Far more insidious, however, is the well-intentioned but ill-conceived "chartjunk" (Tufte's term) intended to enliven and entertain. Herdeg (1981), a classic catalog of lively diagrams now in its fourth edition, presents numerous examples of imaginative and appropriate work interspersed with chartjunk. Holmes (1984) is even more replete with chartjunk. The student should look at these various books and think about what makes a visual presentation effective.

The advanced student can eventually progress to the monumental works of Tukey and Bertin. Tukey (1977) focuses on the exploratory analysis of data, and the use of novel forms of graphic presentation to assist in the task. Bertin (1983) begins from a cartographic perspective, but enlarges this to a comprehensive exploration of methods of applying graphic presentation to the construction of complex yet communicative diagrams, networks, and maps.

Colour

Colour is another key component of computer-generated graphics. The appropriate use of colour is difficult. Our reactions to colour result from a complex set of physio-

Case Study D

The Star, the Lisa, and the Macintosh

We have seen in Chapter 13: Enhancing System Usability that the concept of a user interface must be defined very broadly to include not only the dialogue structures, presented in Chapter 10: Interaction Styles and Techniques, but also a system's documentation, error messages, help structures, training materials, and user support system. Even doing all this, however, is no guarantee that a product will succeed, as we shall now see.

The Xerox Star

It should be clear from many of the preceding chapters that, in the 1970's, the Xerox Palo Alto Research Center (PARC) was an environment of enormous creativity. It was the site of pioneering work in the design of new personal workstations, in the invention of interactive techniques to exploit their capabilities and facilitate their use, and in the development of an applied cognitive psychology to help guide appropriate design. These activities finally resulted in the announcement, in April 1981, of the 8010 Star Information System, "a new personal computer designed for offices ... intended for business professionals who handle information" (Smith, Irby, Kimball, Verplank, and Harslem, 1982, 1983). Star was probably the first comprehensive direct manipulation system intended for a business application in an office environment.

Star was greeted with much enthusiasm, particularly because it codified and made available, for the first time in a commercial product, many of the user interface ideas developed or refined at PARC in the 70's:

- A familiar *user's conceptual model* employing icons and windows on a simulated "desktop."
- The ability to see and point rather than to remember and type on a keyboard.
- The use of *property* or *option* sheets to specify the appearance of objects.
- *What you see is what you get* (WYSIWYG).
- *Universal* or *generic* commands (Rosenberg and Moran, 1984), that is, a few commands such as MOVE, COPY, and DELETE that can be used throughout the system.
- A relatively high degree of consistency and simplicity.
- *Modeless* interaction (Tesler, 1981).
- A certain amount of user tailorability.

Further details about these principles may be found in Smith, Irby, Kimball, Verplank, and Harslem (1982, 1983), which is included here as a reading. A more technical description of the interface components appears in Smith, Harslem, Irby, and Kimball (1982). Other relevant papers are Thacker et al. (1982), which describes the prototype Alto computer on which much of the underlying research and development was done; Harslem and Nelson (1982), which describes the Star development environment and process; Lipkie, Evans, Newlin, and Weisman (1982), which describes the graphics implementation; and Purvy, Farrell, and Klose (1983), which describes the Star's records processing capability.

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The high quality of the Star user interfaces was only partly due to inspired design based on a decade of creative and relevant research and development (Pake, 1985; Perry and Wallich, 1985). Another factor was the extensive use of prototyping of ideas, pencil-and-paper analyses, and human factors experiments with potential users. Some of these experiments are described in Bewley, Roberts, Schroit, and Verplank (1983) which is also included as a reading.

How did Star fare in the marketplace? It was not a smashing commercial success. One can hypothesize a number of reasons for this:

1) It was a pioneering system both in terms of its user interface and of its orientation towards the "knowledge worker" as the intended user. Often the technological trailblazer only paves the way for a second or third product to be successful. Xerox was simply too early; the "knowledge worker" market did not exist in 1981.

2) Including a proportional share of the "file servers" and "print servers" that were part of the network, each individual Star cost an amount approaching $15,000. At that time, this was considered too expensive relative to the perceived benefit.

3) The Star possessed very limited functionality relative to the customers and purposes for which it was intended. In discussing what he calls "the office automation (OA) mirage," Hammer (1984) writes:

> The following list indicates the actual relative importance of various aspects of an OA system:
> 1. Functionality
> 2. Functionality
> 3. Nothing
> 4. Functionality
> 5. Everything else
>
> The questions that will guide the perplexed through the OA maze (and that would have saved many a vendor from extinction) are these: who will use this product, what will they use it for, and why will they be better off for using it? This acid test can be used to explain otherwise puzzling phenomena. For example, the Xerox Star (8010) was widely hailed upon its introduction as the harbinger of a new age. The Star was positioned as a management/professional workstation; it used a high-resolution screen and employed a user interface based on icons and a mouse. It was intended to advance OA beyond secretarial word processing to the manager and professional. It sank like a stone. Even a casual inspection of the Star's functionality would have predicted this result. The Star did not provide any management/professional applications worthy of the name. It had a host of adequate administrative support applications and a very good word processor, but nothing that would address the business needs of its intended users. (In fact, the one market in which the Star has achieved some success is in the high end of word processing.) The reports in the press were enthusiastic to the point of sycophancy, but even they should have aroused

suspicion, for they focused exclusively on the Star's interface, not on its capability.

> Vendors have learned a lesson about ease of learning, ease of use, friendly interfaces, and the like, but unfortunately it is the wrong lesson. They have been roundly (and appropriately) chastised for the often unusable interfaces that their systems presented to users; it has finally sunk in that expressing oneself in JCL is an unnatural act. From this, the vendors have reached the imaginative conclusion that a good user interface covers all sins. They have forgotten two laws of nature: first, people buy systems for functions, not for interfaces; and secondly, when a vendor talks about interface, it means he has nothing else to say.
>
> In reality, user interface is a second-order factor. All other things being equal, the system with the better interface is to be preferred. But a system with better functionality will almost always win over one with a better interface....

4) The Star lacked an open architecture, a set of technical and administrative mechanisms to encourage third party software developers to create new software for the system. The CUStomer Programming (CUSP) system that was supplied (Purvy, Farrell, and Klose, 1983), a record processing language that for some time was not even a full programming language, was not suitable for the development of applications. Xerox was for a long time unwilling to license to third parties the tool they themselves had used for their programming, the Mesa development environment (Mitchell, Maybury, and Sweet, 1978; Horsley and Lynch, 1979; Lauer and Satterthwaite, 1979; Johnson and Wick, 1982).

5) The Star was perceived as slow. Roberts and Moran (1983) show that, despite the system's long response time, it was one of the two best of nine text editors evaluated, in terms of the average time required to carry out a set of benchmark tasks. However, it is the *perception* of human users, and not any abstract *reality*, that is the ultimate determinant of user satisfaction.

6) It may be that the skills and methods applicable to the marketing and sale of photocopiers were not directly applicable or quickly adaptable to the sale of office automation workstations for knowledge workers.

The Apple Lisa

It is said that Steven Jobs, Apple's founder and Chairman, was incredibly impressed with the bit-mapped displays and the applications running on them that he saw in a visit to Xerox PARC in 1979 (Perry and Wallich, 1985, p. 72). The result was that, early in 1983, Apple introduced the Lisa, a product similar to the Star in terms of its user interface (but see Marcus, 1984, for a discussion of some fine distinctions). There were a number of important differences between the two products:

- Star was much more ambitious than Lisa in providing networking and distributed computing.
- At roughly $10,000, Lisa was somewhat less expensive than Star.
- Lisa was positioned somewhere between an office system and a personal productivity tool, one that could be used by individuals for such tasks as editing documents, building forecasting models with spreadsheets, and managing small data bases.

Williams (1983) describes the design and the user interface of the Lisa. Morgan, Williams, and Lemmons (1983) discuss the design process. Apple's ongoing attempts to upgrade and revitalize the product are documented in Williams (1984a,b), Redhed (1984) and a video (Apple, 1983). An illuminating observational study of users learning the Lisa is that of Carroll and Mazur (1986). In contrast to the other glowing accounts of Lisa's usability, this study shows that even a highly crafted and successful user interface can still have significant weaknesses.

The Apple Macintosh

Because of its cost, its confused product positioning, and its inadequate base of software and applications, Lisa also was not successful, and was withdrawn within three years. Finally, in January of 1984, Apple introduced the Macintosh at a price of approximately $2,500. Why, in contrast to the Star and the Lisa, did the Macintosh succeed so well?

1) The Mac did not need to trailblaze. Star and Lisa had prepared the ground in terms of the user interface. Numerous companies, including IBM, had opened up the market for professional personal computers.

2) Since the Mac was in a sense a second generation Lisa, Apple had the opportunity to learn from experience and eliminate many of the bugs (Tognazzini, 1985). There were a number of user interface improvements along the way from Star to Lisa to Mac.

3) The product was very aggressively priced.

4) Although initial product functionality was quite limited, a partially open architecture, a powerful developer's toolkit (Apple, 1985), and an aggressive program of third party software development soon led to the widespread availability of a great variety of significant software product offerings (McCroskey, Mellin, and Ritz, 1985).

5) The excellent graphics and the availability of a reasonably priced 300 dot per inch laser printer (the Laserwriter) allowed the Macintosh to achieve early domination in the emerging market of *desktop publishing*. Again, Apple's timing was better than Xerox's. Although Xerox had done the pioneering work on the computer-controlled laser printer (Pake, 1985; Perry and Wallich, 1985), Apple was able to commercialize a high quality implementation of the concept at a reasonable price.

6) Apple was able to draw upon a number of years of successful experience in the personal computer business, and upon attendant marketing expertise, distribution channels, and skills in sales and support.

Williams (1984c) and Webster (1984) describe the design and the user interface of the Macintosh. Lemmons (1984), Markoff and Shapiro (1984), and Guterl (1984) discuss the design process. Jennings (1984) is a critical evaluation of the functionality and user interface of the Macintosh Finder, which provides the Macintosh equivalent of the command level interface to the operating system in a traditional computing environment.

Conclusion

The message is simple. The best user interface work in the world may be wasted if it is not coupled with a product that offers significant functionality at a reasonable price, is introduced in a timely fashion, and is well marketed to an appropriately targeted group of customers. Furthermore, if there must be a tradeoff between functionality and the user interface, functionality must be given the higher priority.

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Exhibit S

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Exhibit T

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CERTIFICATE OF SERVICE

I, Rodger D. Smith II, hereby certify that on November 15, 2005, I caused to be electronically filed the Appendix of Exhibits in Support of Scientific Games' Opening Brief in Support of Its Motion for Summary Judgment (Redacted Version) with the Clerk of the Court using CM/ECF, which will send notification of such filing(s) to the following:

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and that I caused copies to be served upon the following in the manner indicated:

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